POSITIONING SYSTEM FOR CDMA/PCS COMMUNICATIONS SYSTEM

REFERENCE TO RELATED APPLICATION

This application is the subject of provisional application Ser. No. 60/038,836 filed Feb. 18, 1997 and entitled POSITIONING SYSTEM FOR CDMA/PCS COMMUNICATIONS SYSTEM. Reference is also made to application Ser. No. 09/025,093 filed concurrently herewith entitled A PHASE AGILE ANTENNA FOR USE IN POSITION DETERMINATION which is incorporated herein by reference.

This invention relates to a positioning system and more particularly to positioning systems for use with code division multiple access (CDMA)/personal communication services (PCS).

BACKGROUND OF THE INVENTION

In wire telephony, by its very nature, the location of a caller can usually be determined from knowledge of the number assigned to the subscriber line. The principal feature of cellular radio telephony is that the caller can be anywhere within an assigned service area, which in some instances means almost anywhere in the world where compatible cellular service is available.

In cellular telephony, a caller's location can be identified only as to the cell in which the caller is currently communicating, though no provisions for reporting and tracking location are ordinarily provided in such systems. Cells are defined by coverage of individual base station antennas, and at a given base station site are commonly divided, like wedges of a pie, through use of co-located directional base-station transmitting and receiving antennas, each antenna serving an angular sector of, for example 120 degrees around the antenna site.

OBJECTIVES OF THE INVENTION

In many different applications of mobile telephony, it is of value to know with precision the location of a particular subscriber set (Mobile Station). One example is in handling calls for assistance using the emergency number 911, or similar commercial 811 numbers. In conventional cellular telephony, a caller must tell the emergency equipment dispatcher his or her location. Callers frequently do not know their location, in an emergency or otherwise.

Another example is the dispatching of commercial taxis or emergency vehicles using cellular telephone rather than a private radio channel. The vehicle closest to the site of a need for service is an obvious candidate for dispatch to that site, if available, and can be contacted individually through cellular telephony, rather than by area broadcast. Law enforcement officials could also maintain court-approved surveillance on criminal suspects who carry and use cellular phones. Another example is at construction sites where it is desirable to know the location of various pieces of mobile construction equipment and at the same time provide two-way communication between the various pieces of equipment. Another example where the invention can be used is for surveillance of ground traffic at congested airports.

Applications are not limited to outdoor venues. Using this invention, the location of a manager or of service personnel could be determined within a large commercial or industrial installation or office building, and an individual contacted if it is appropriate to do so at his or her present location. The invention can be applied in industrial areas requiring precision location (positioning) of tools and/or objects.

In implementing such a capability, particularly digital cellular telephony, it is highly desirable that it not require modification of the numerous subscriber units (Mobile Stations, cellular handsets, etc.). This is a primary goal of this invention. Since a Mobile Station may be in motion at the time of a call, as for example in a situation where a driver is unsure of his or her location, it is also desirable that the measurement be made accurately within a short time interval.

PRINCIPLES

This invention makes used of well-known principles of radiolocation applied through the medium of cellular telephony, by use of additional hardware and software at Base Station and at higher network levels.

The present invention locates the position of a mobile user handset or mobile station (MS) without modification of the handset or mobile station.

Working with existing base of user handsets (Mobile Stations) leads to a "Network Centric" solution:

- Network centric solutions that use Base Station measurements of Mobile Stations (MS) transmissions on the reverse channels can work with unmodified MSs.
- "Phone Centric" solutions which rely upon measurements that the MS base stations require MS modification.

Requirement for Good coverage throughout the CDMA system service area leads to a positioning technique that can work with measurements from a single Base Station:

- Strict MS transmit power control ensures a lean margin that minimizes system self interference; in a CDMA system service area, the MS transmissions on a reverse channel frequently can be heard by only one Base Station.
- The coverage area over which the MS transmission on a reverse channel is received by 2, 3 or more Base Stations is very poor—the "donut hole" problem.

The Positioning System disclosed herein works with measurements from a single Base Station:

- A true range measurement (two-way range),
- A bearing measurement,
- Range and bearing specify the location of the MS.

Direction Finding

In this invention a directional antenna is added to each base station to permit it to determine bearing or azimuthal angular position of any mobile station during normal two-way communication with the base station. The term Position Location Monitor (PLM) is used to identify the additional equipment associated with the base station to provide location information on the mobile station.

Range Determination

In conventional radars, range estimation ("ranging") is done by determining the time required for a pulsed signal to reach the "target" and subsequently for its echo to return to the radar receiver. This time is multiplied by the velocity of light and radio waves (approximately 186,000 miles per second) to determine two-way range, or halved to find one-way range.

The present invention applies to cellular telephone systems that communicate using digital modulation, such as Code Division Multiple Access communications. In this signaling method, digitally coded information modulates a repetitive pseudo noise (PN) pulse train whose transitions ("chips") occur at a much faster rate than the digital information, the result being that the bandwidth required is "spread" to be much broader than the original data band-